HEMODIALYSIS: BASICS

By

Ahmed Mohammed Abd El Wahab

Lecturer of internal medicine (Nephrology)

Dialysis

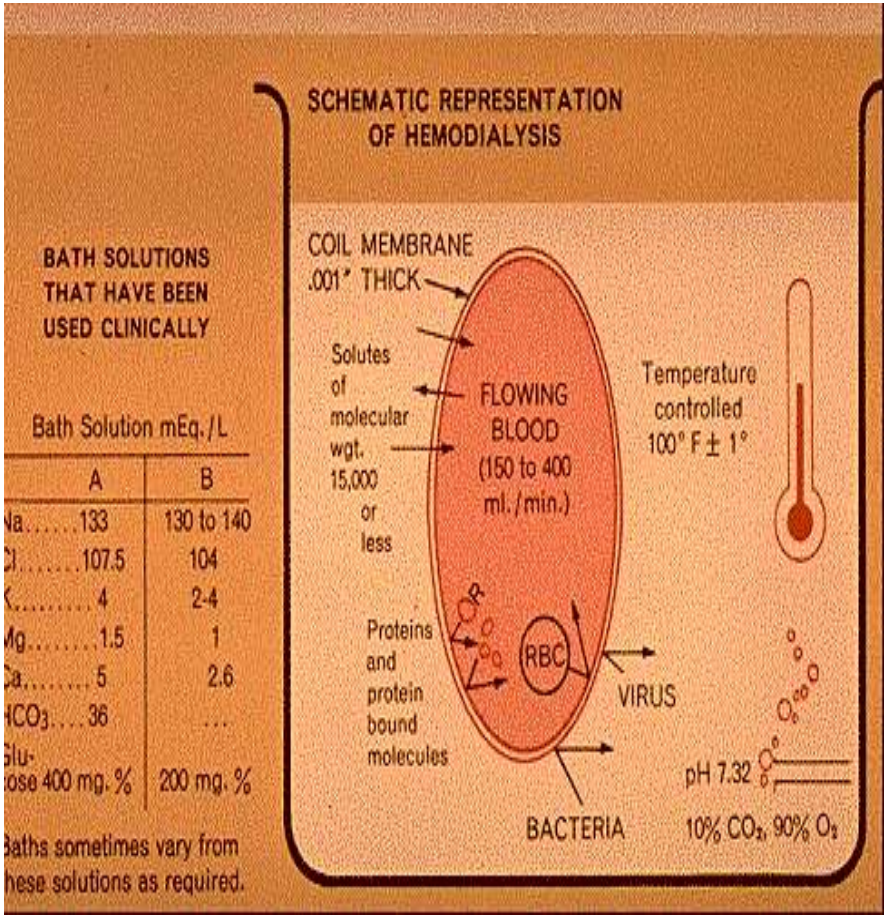
Process by which the solute composition of a solution "A" is altered by exposing it to a second solution "B" through a semi-permeable membrane

Necessary pre-requisites for Hemodialysis

1) Semi-permeable membrane

2) Anticoagulation

3) Knowing what to remove and how much of it



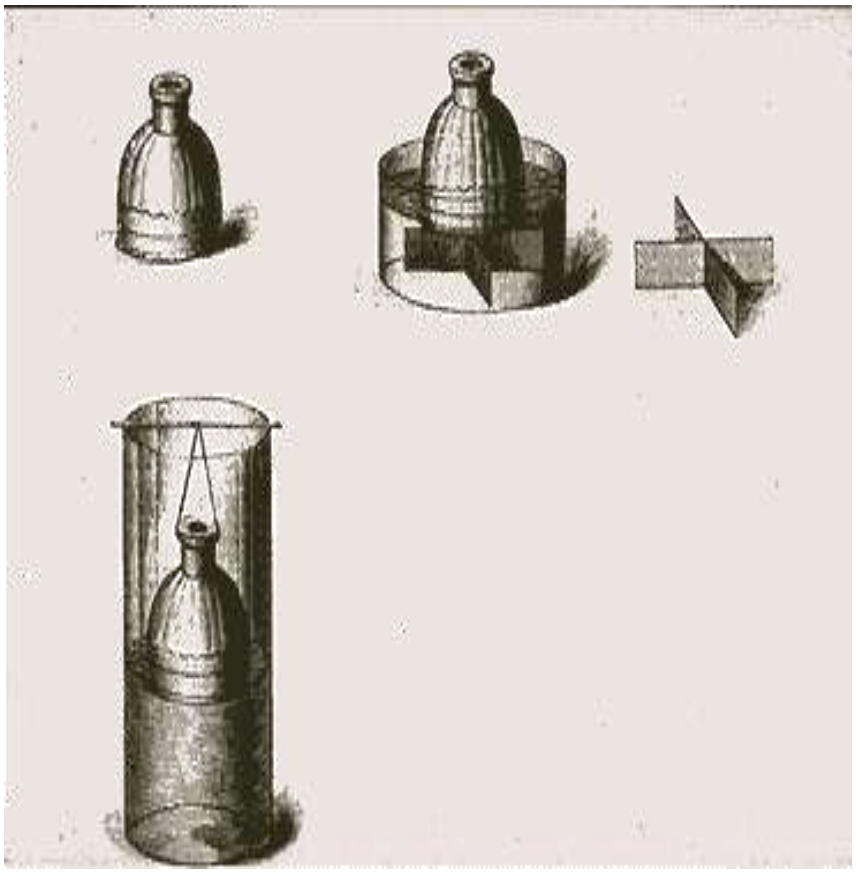
1773: Nurepuel isolates Urea by boiling urine in a pan

1828: Wohler synthesizes Urea and describes its molecular structure

Thomas Graham (1805-1869)

1850 Glasgow, Scotland:

Thomas Graham ‘s experiment to demonstrate diffusion across a semi-permeable membrane (Pergamon paper)



Claude Bernard, 1813 to 1878.

Sept. 1, 1888.]

THE BRADSHAWE LECTURE

ON

URÆMIA.

Delivered before the Royal College of Physicians, August, 1888.

BY WILLIAM CARTER, M.D., B.Sc., LL.B.Lond., F.R.C.P.Lond.,

Physician to the Royal Southern Hospital, Liverpool; Professor of Materia Medica and Therapeutics, in University College, Liverpool.

Dialysis Membranes

- 1750:Advances in the dovelopment of smokeless gunpowder led to the synthesis of a strong Nitrocellulose called “collodion”. It was a combination of Nitric acid and cotton
- Addition of Camphor to this substance led to the synthesis of stable and strong “plastics”
- 1957:Helmut Staldiger polymerized “Cellulose”

1913:The First Hemodialysis Experiment

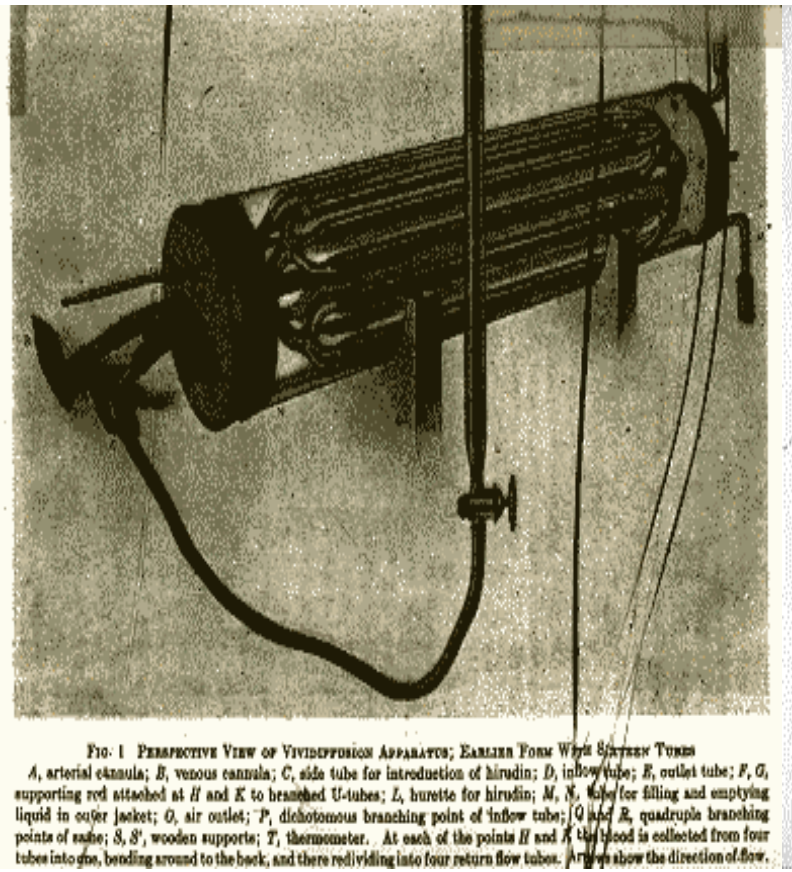


FIG. 1 PERSPECTIVE VIEW OF VIVIDIFFUSION APPARATUS; EARLIER FORM WITH SIXTEEN TUBES

A, arterial cannula; *B*, venous cannula; *C*, side tube for introduction of hirudin; *D*, inflow tube; *E*, outlet tube; *F*, *G*, supporting rod attached at *H* and *K* to branched U-tubes; *L*, burette for hirudin; *M*, *N*, tube for filling and emptying liquid in outer jacket; *O*, air outlet; *P*, dichotomous branching point of inflow tube; *Q* and *R*, quadruple branching points of same; *S*, *S'*, wooden supports; *T*, thermometer. At each of the points *H* and *K* the blood is collected from four tubes into one, bending around to the back, and there redividing into four return flow tubes. Arrows show the direction of flow.

ON THE REMOVAL OF DIFFUSIBLE SUBSTANCES FROM THE CIRCULATING BLOOD OF LIVING ANIMALS BY DIALYSIS

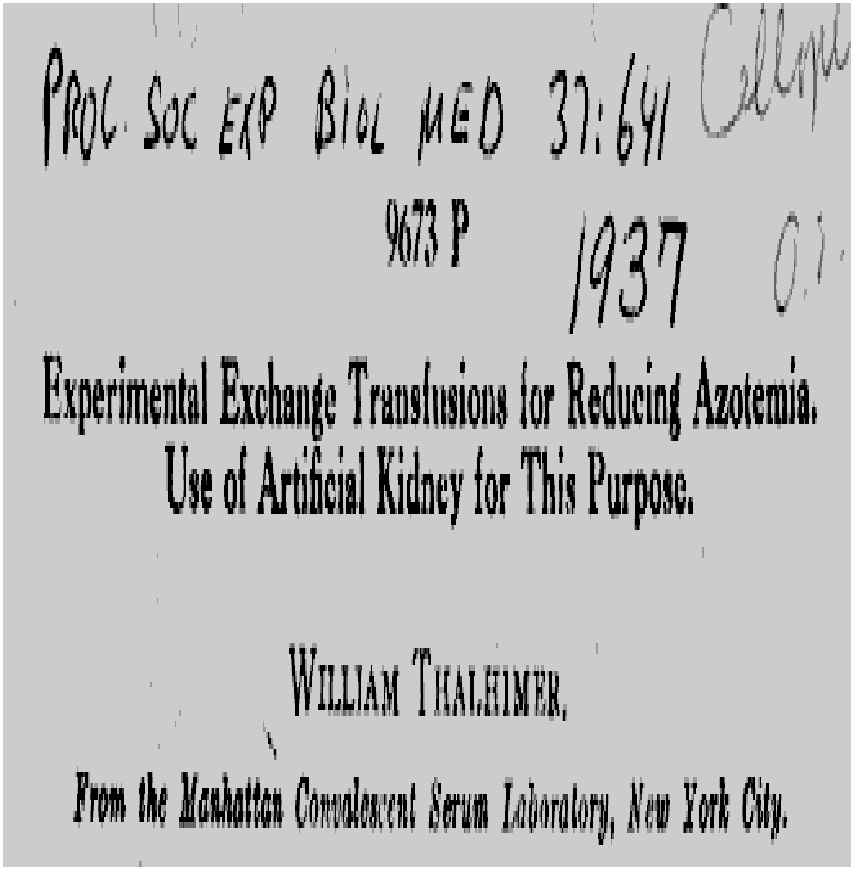
JOHN J. ABEL, LEONARD G. ROWNTREE AND B. B. TURNER

From the Pharmacological Laboratory of the Johns Hopkins University

Received for publication, December 18, 1913

CONTENTS

1937: William Thalhimer successfully lowers BUN by performing Hemodialysis in anephric dogs



PROC. SOC EXP BIOL MED 37: 641

9673 P 1937

Experimental Exchange Transfusions for Reducing Azotemia. Use of Artificial Kidney for This Purpose.

WILLIAM THALHIMER,

From the Manhattan Convalescent Serum Laboratory, New York City.

1926:The First Human Experiment

- George Haas used a collodion tube arrangement to successfully dialyze human subjects
- Allergic reactions to impurities in Hirudin led him to abandon his experiments

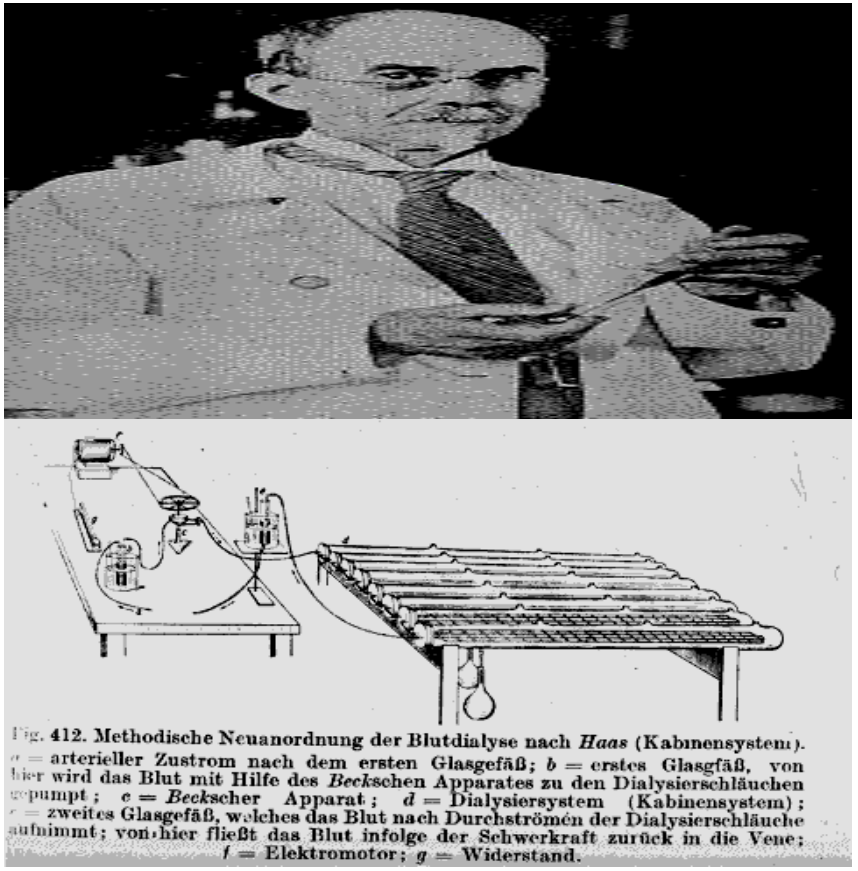
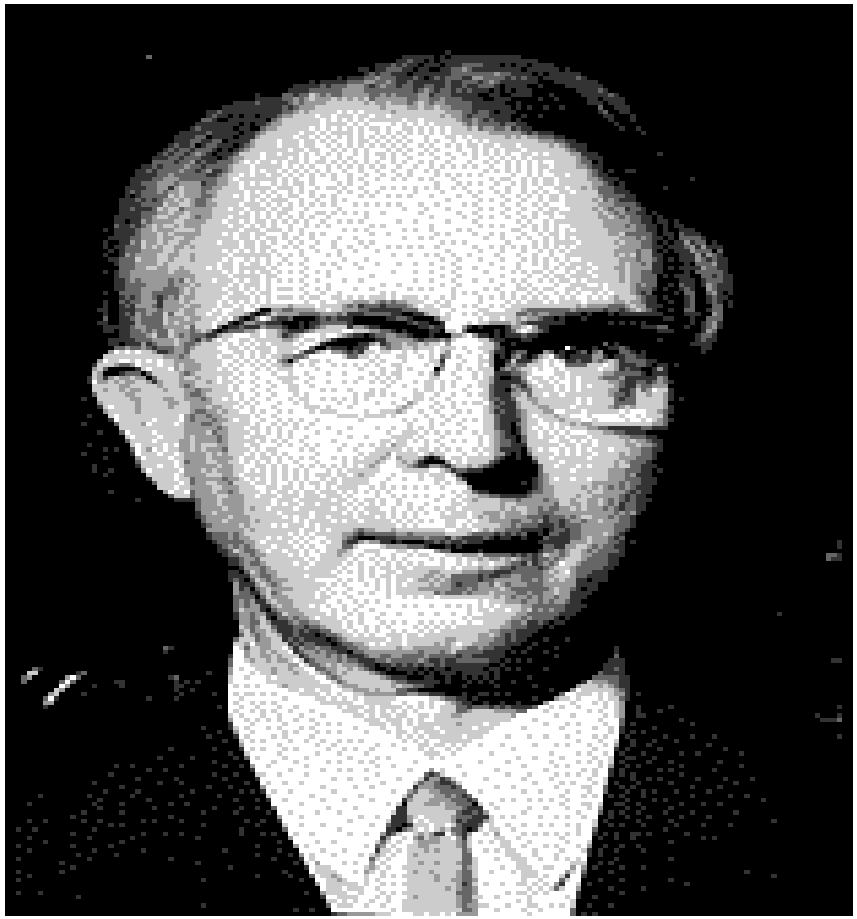
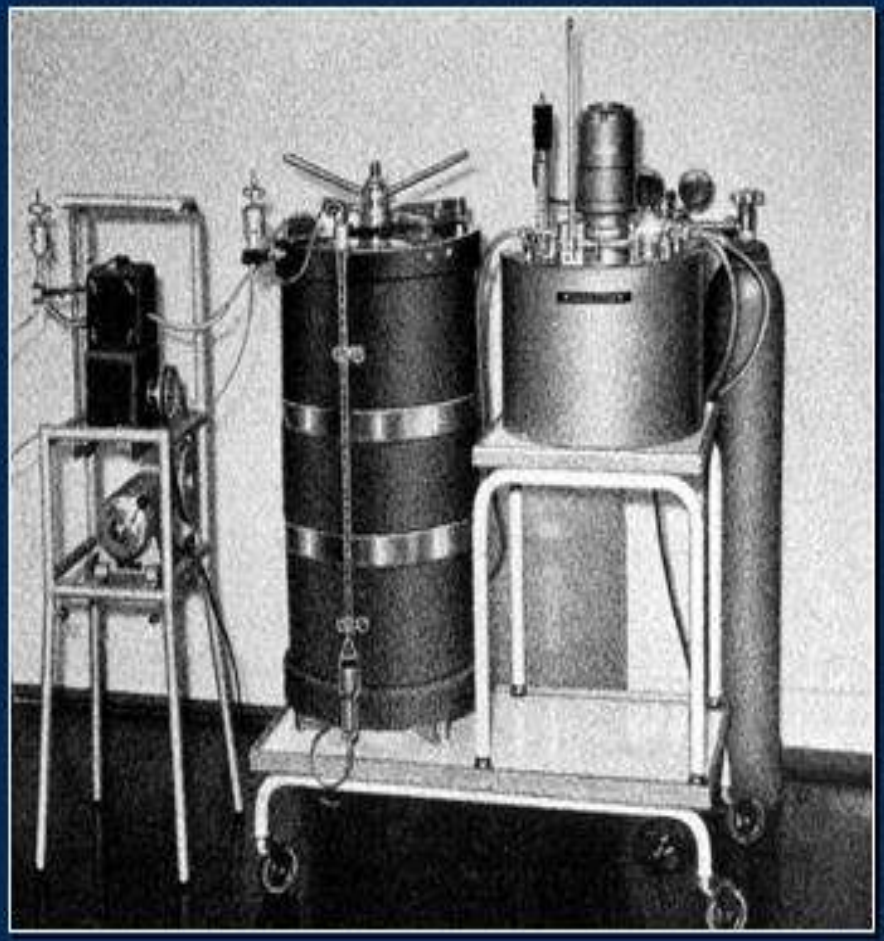


Fig. 412. Methodische Neuanordnung der Blutdialyse nach *Haas* (Kabinensystem). *a* = arterieller Zustrom nach dem ersten Glasgefäß; *b* = erstes Glasgefäß, von hier wird das Blut mit Hilfe des *Beck*schen Apparates zu den Dialysierschläuchen gepumpt; *c* = *Beck*scher Apparat; *d* = Dialysiersystem (Kabinensystem); *e* = zweites Glasgefäß, welches das Blut nach Durchströmen der Dialysierschläuche aufnimmt; von hier fließt das Blut infolge der Schwerkraft zurück in die Vene; *f* = Elektromotor; *g* = Widerstand.

1937:Nils Alwall used the Alwall Kidney to perform the first ever hemodialysis treatment at the university of Lund, Sweden



Alwall Kidney / Working Model

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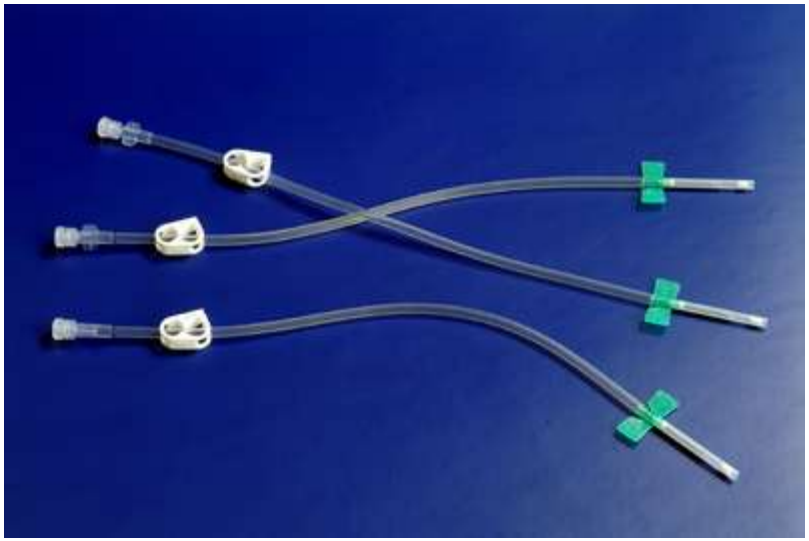
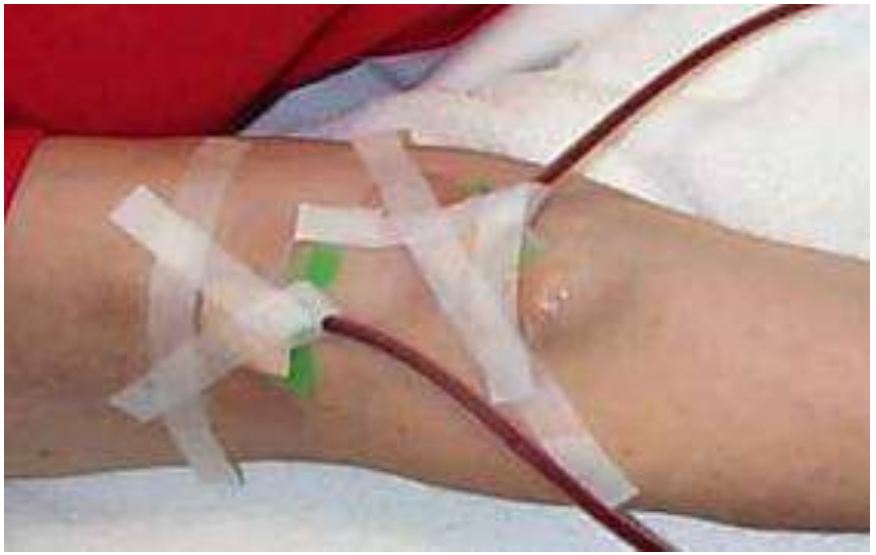
Web site: http://www.sanxin-med. com/en/






Aneurism from
Arterial needle
Fistula
surgery
scar
Aneurism from
Venous needle
White scar
tissue from
site rotation

“ If I have seen farther it is because I have stood on the shoulders of Giants”

Sir Isaac Newton

Hemodialysis:History and Current Perspective

- History of Dialysis
- Principles of Hemodialysis

Mechanisms of Solute transfer

- Diffusion
- Convection
- Osmosis
- Ultrafilteration

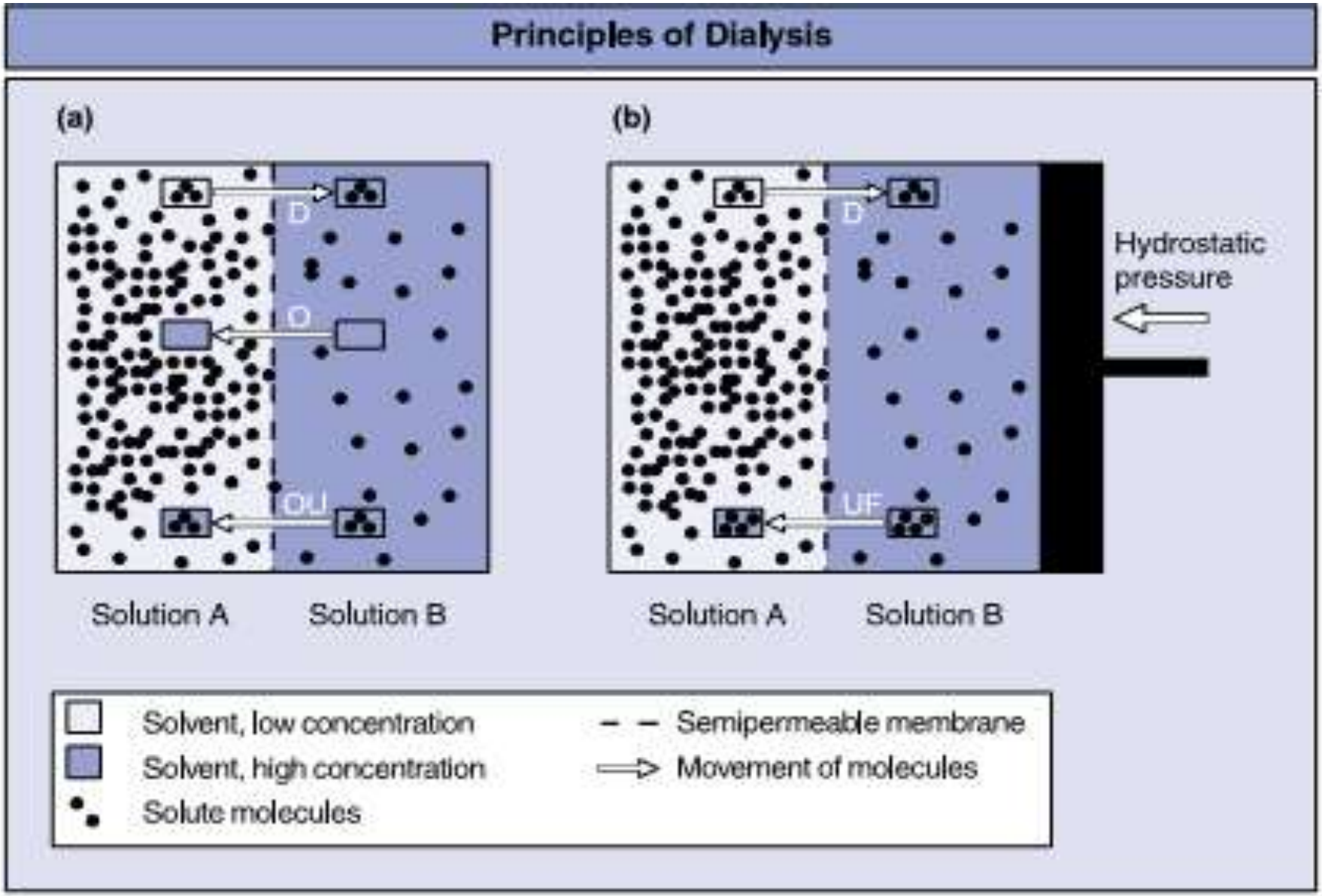


Fig. 1.1 **a** Diffusion, osmosis, and osmotic ultrafiltration by osmotic pressure. **b** Hydrostatic ultrafiltration. *D* diffusion, *O* osmosis, *OU* osmotic ultrafiltration, *UF* ultrafiltration by hydrostatic pressure, *C* convection

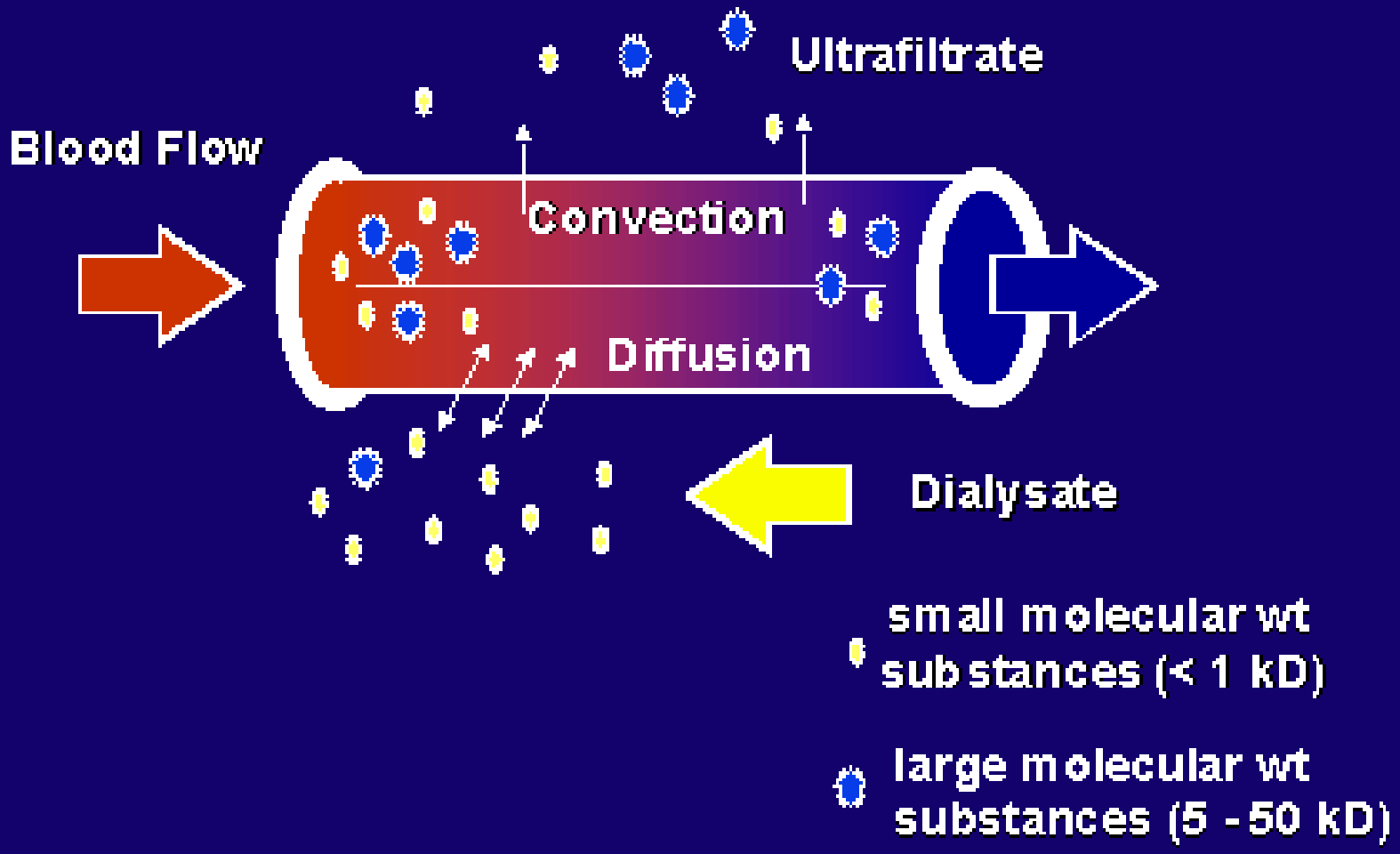
Diffusive Clearance

- A result of random molecular motion
- Influenced by concentration gradient of the solute and its Molecular weight as well as by the membrane permeability to the solute

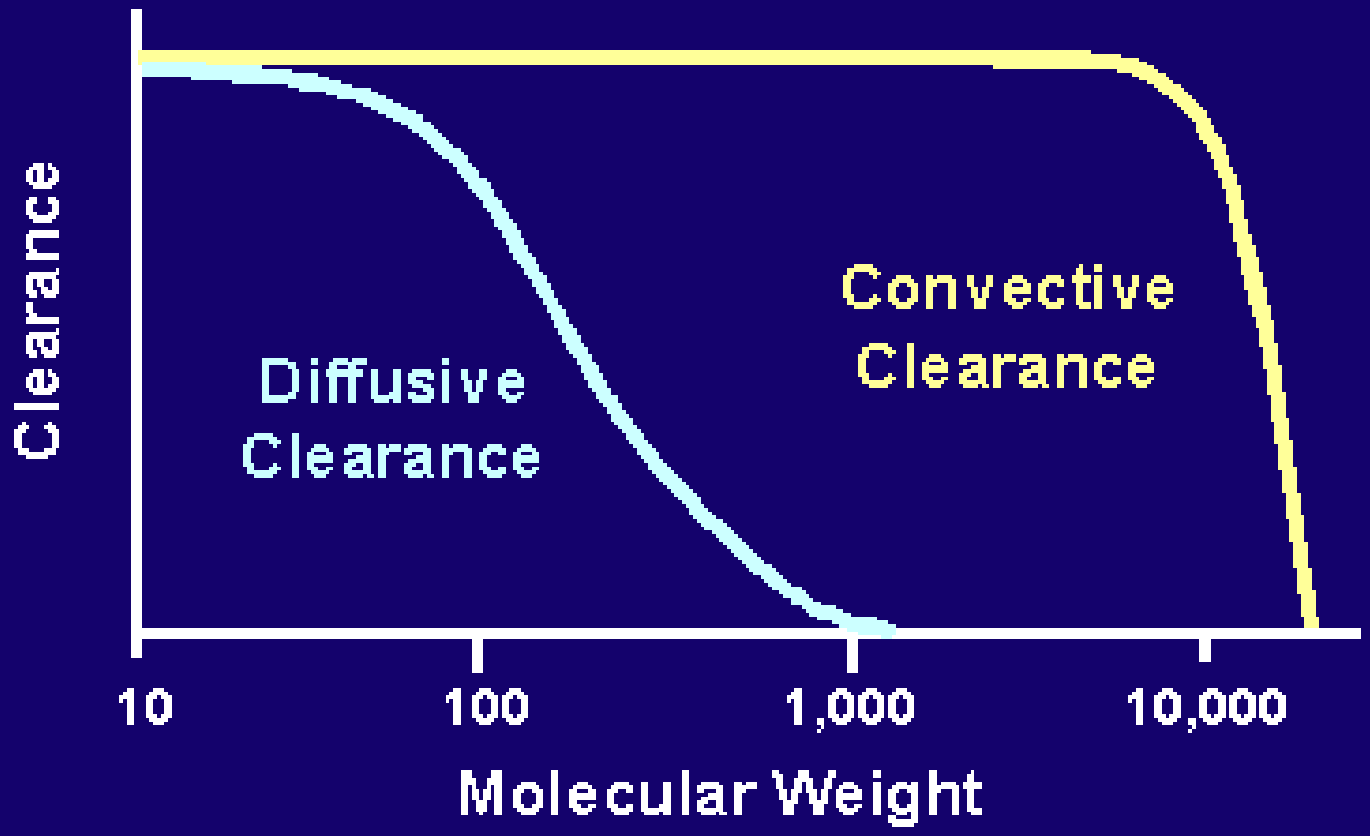
Convective Clearance

- Water molecules passing through a SPM carry with them the solutes in their original concentration. This is called the “solvent drag phenomenon”
- Water can be made to move across a SPM by the application of either a hydrostatic or an osmotic gradient

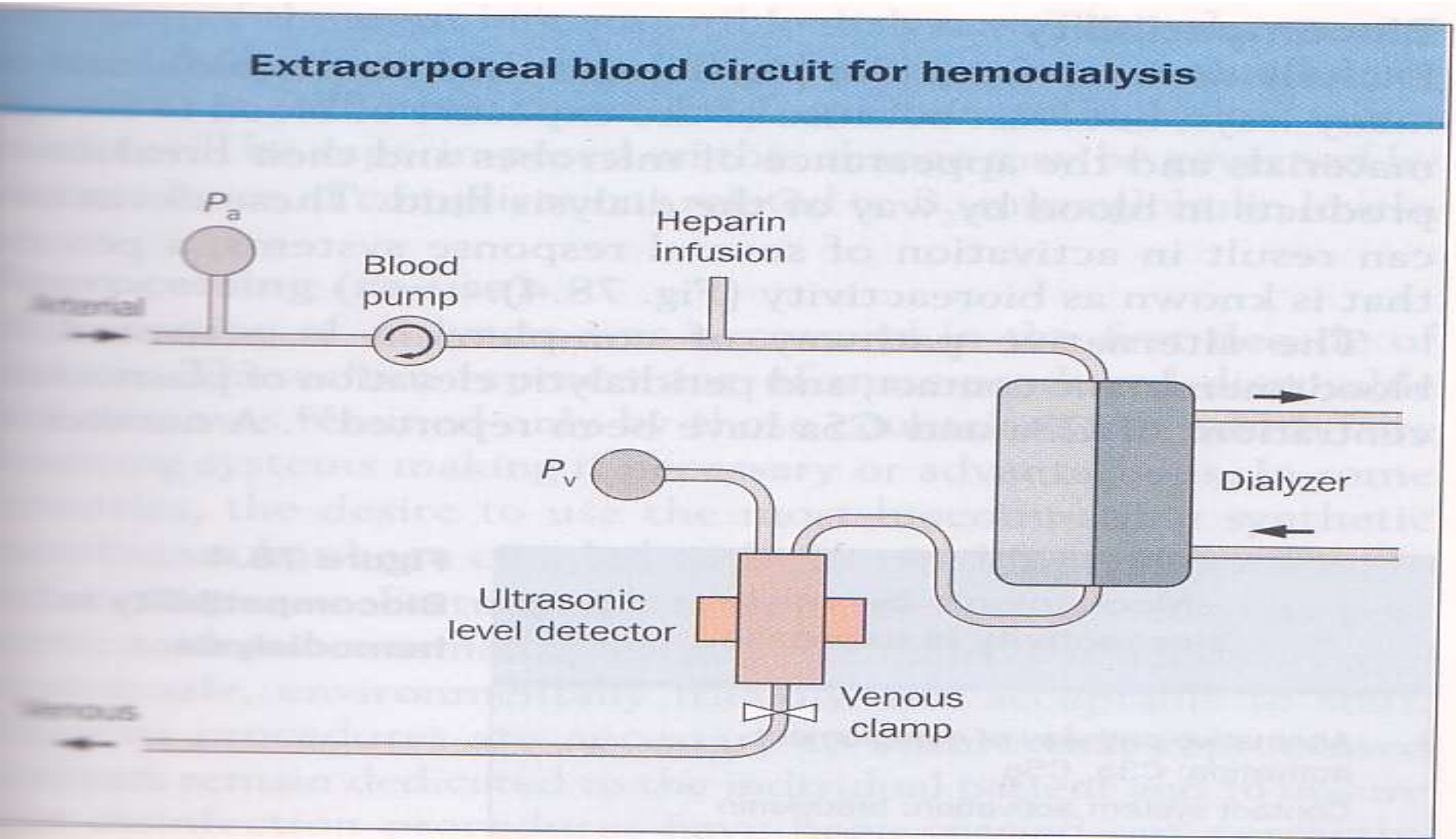
Convection vs. Diffusion



Convection vs. Diffusion



The Hemodialysis circuit



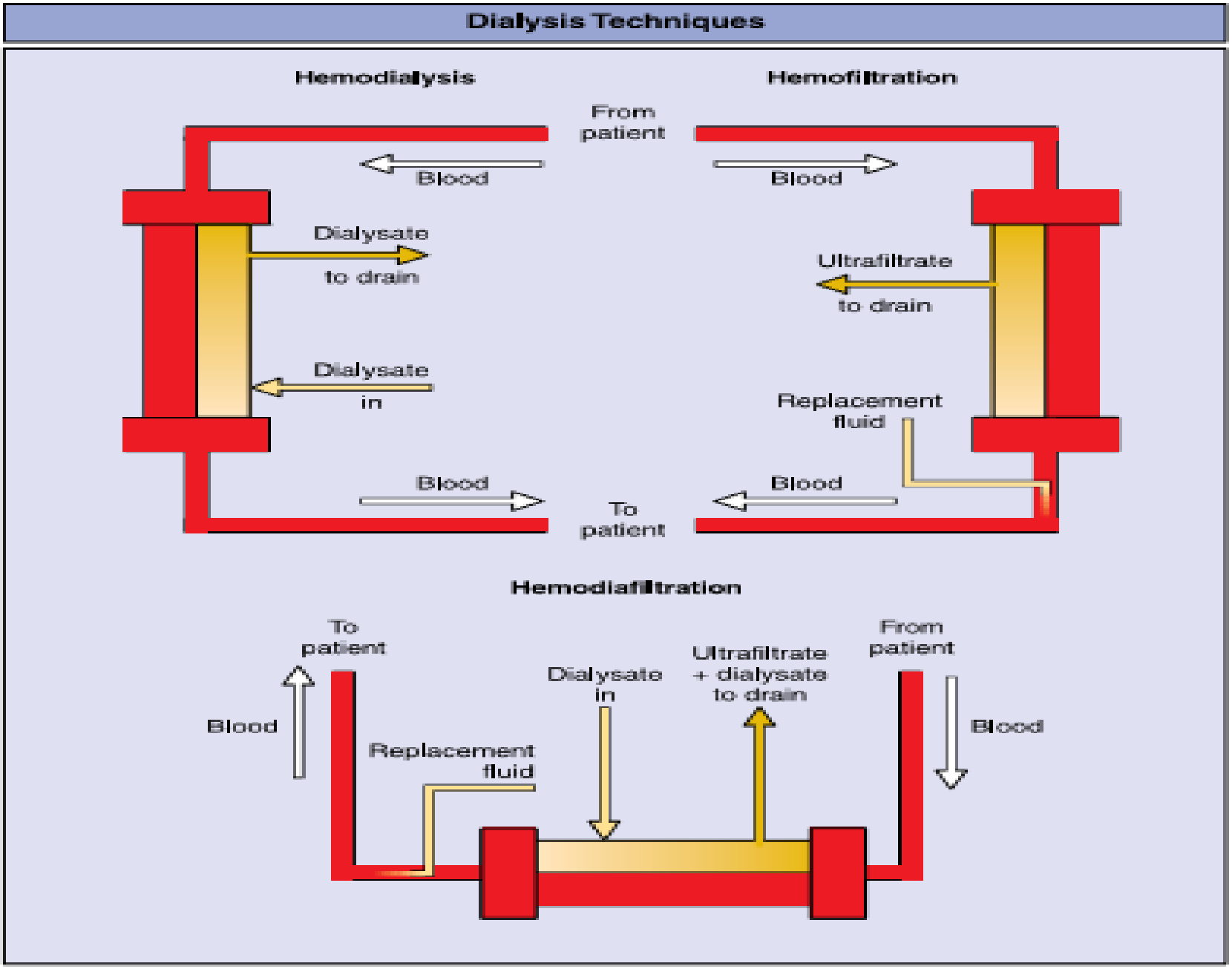


Fig. 2.2 Replacement fluid can be added to the circuit either before (pre-dilution) or after (post-dilution) the dialyzer/filter

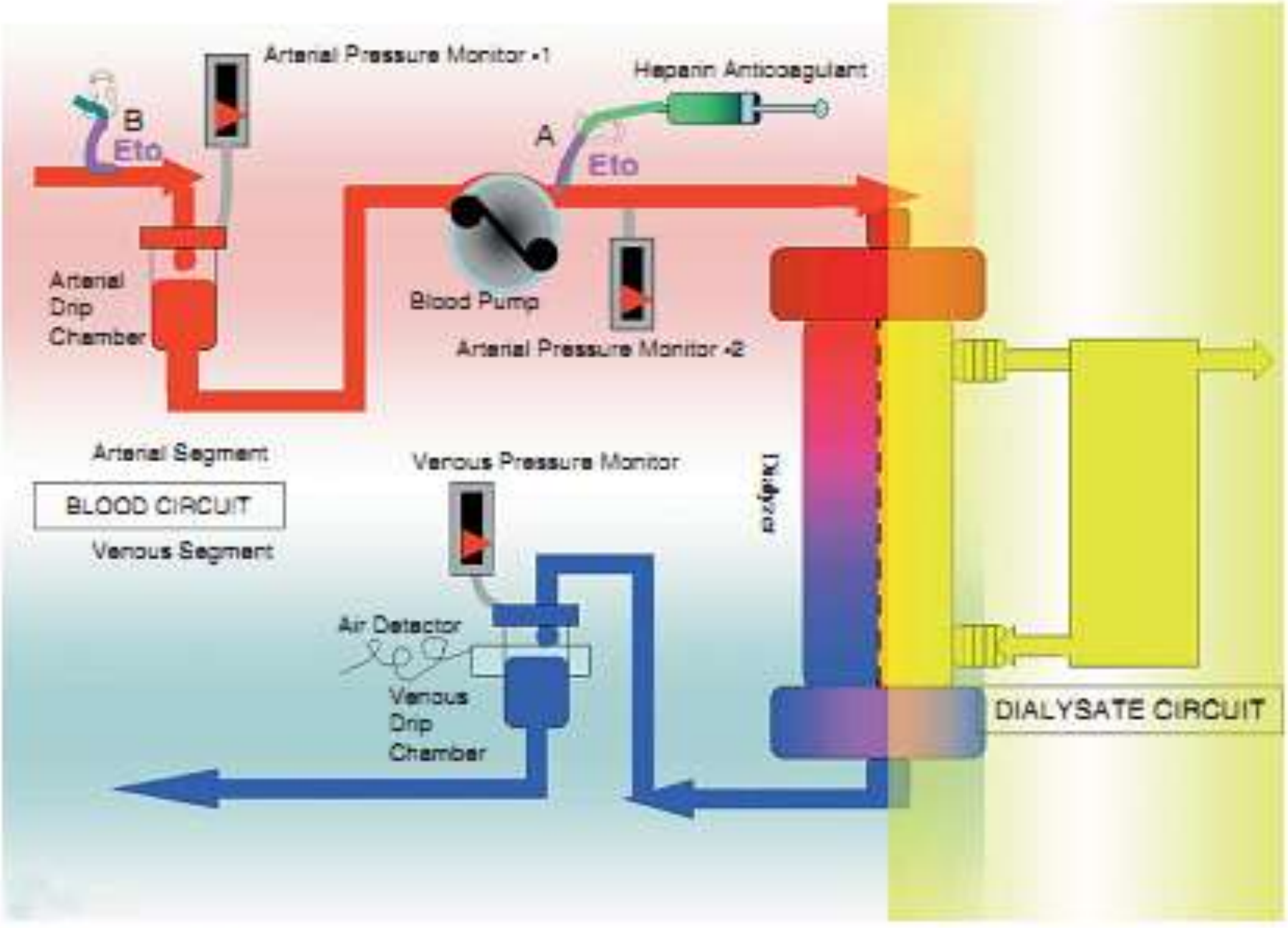
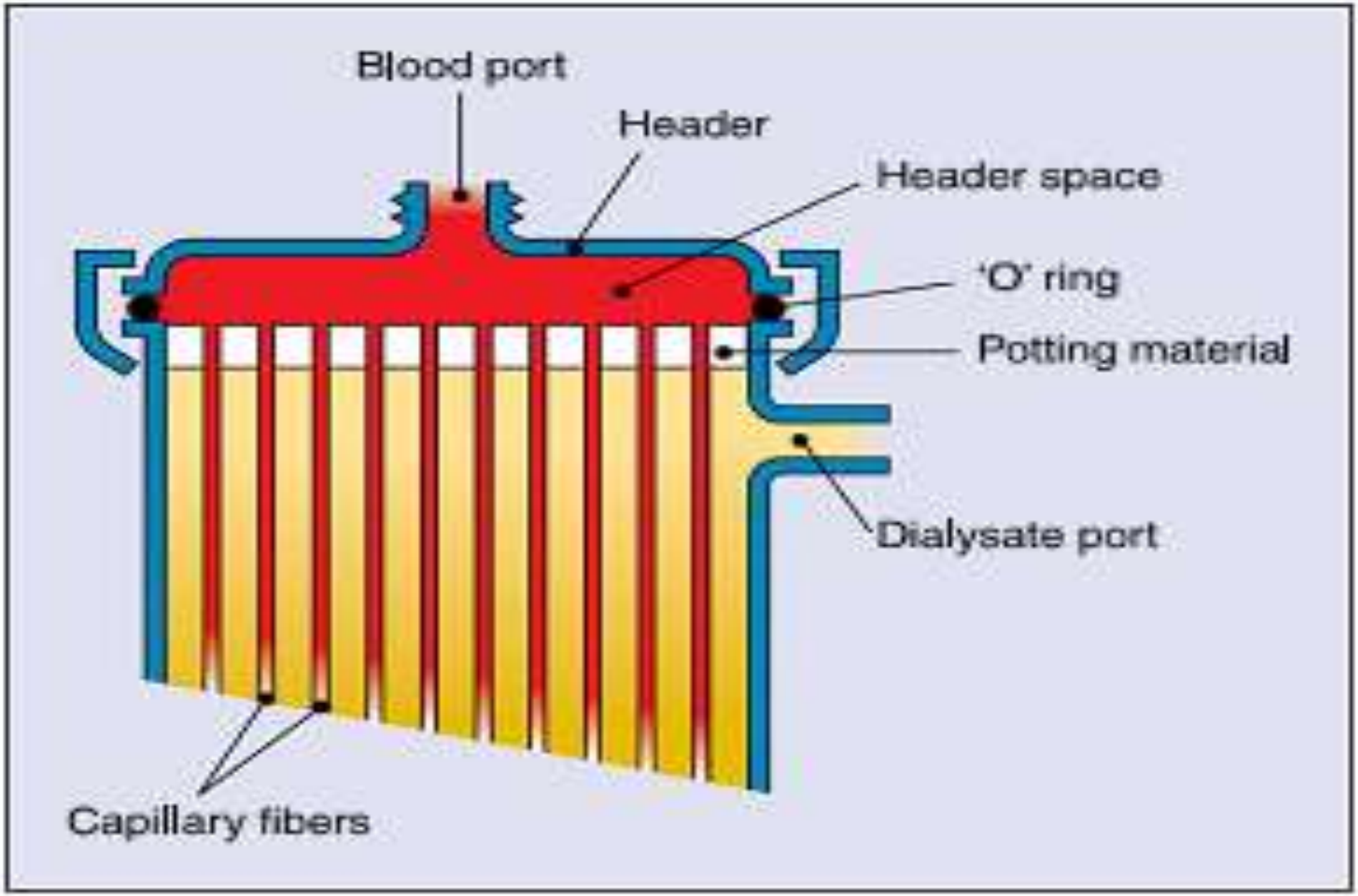


Fig. 2.3 Hemodialysis Setup

Cross Section of a Dialyzer



Dialysis Membranes

Membrane	Hydr.Perm.	Examples	Biocomp.
Regen. cellulose	Low flux	cuprophane	Poor
Modif. Cellulose	Low/High Flux	Cell.acetate Cell di-acet.	Interm.
Synthetic	High/Low flux	PAN,PS,PA, PC,PMMC	Good

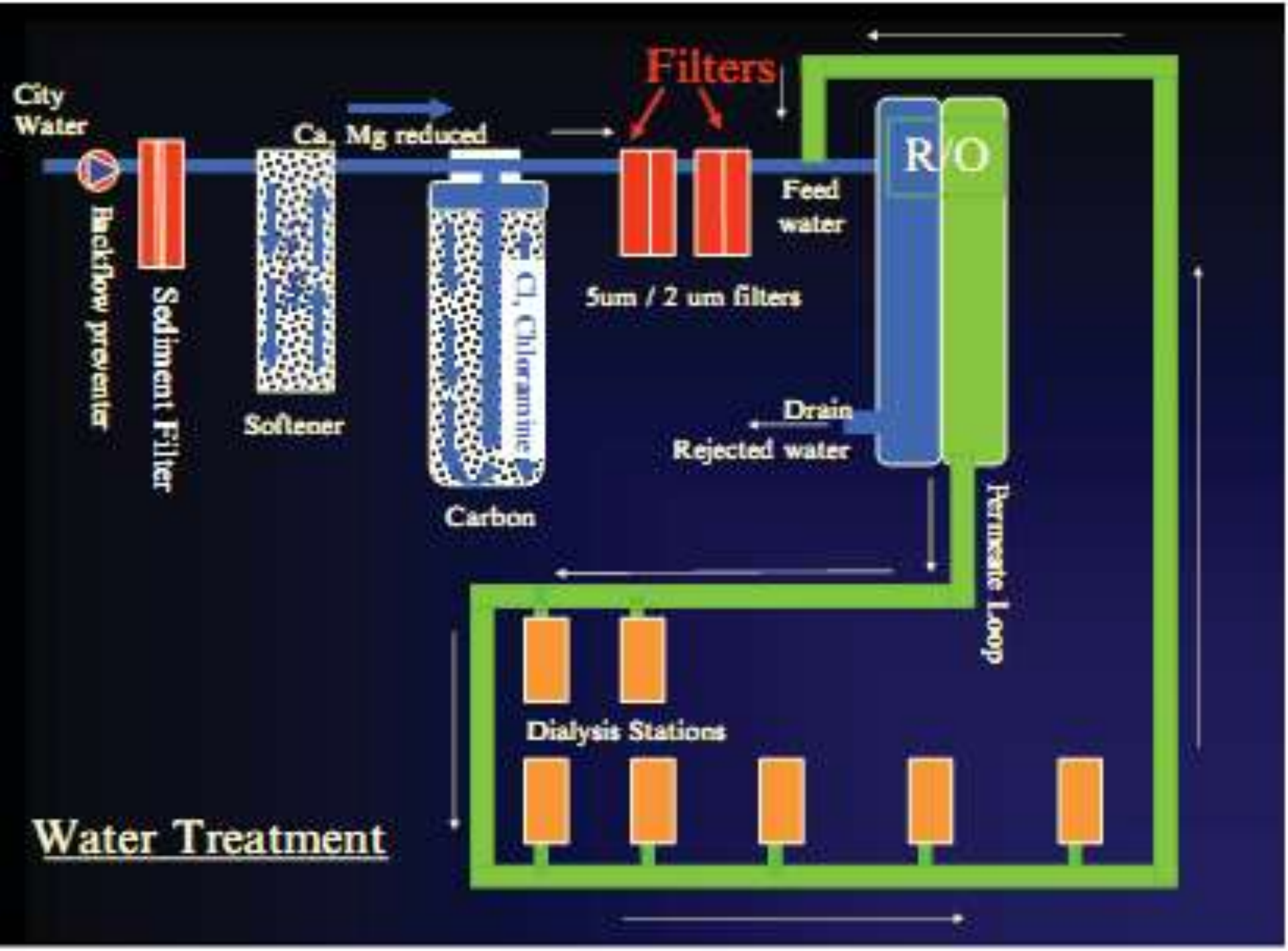
Type of dialysate	Disadvantages	Advantages
Acetate-containing bicarbonate dialysate	Intradialytic complications, Activation of cells Activation of inflammatory proteins	—
Citrate-containing bicarbonate dialysate	Decrease in Ca and Mg	Reduced clotting: • Increase in the dose of dialysis • Heparin-free acute/chronic dialysis • Reduced heparin chronic dialysis • Increase in reuse of dialyzer

The B-concentrate is usually 25 times concentrated and the A-concentrate either 35 or 45 times concentrated.

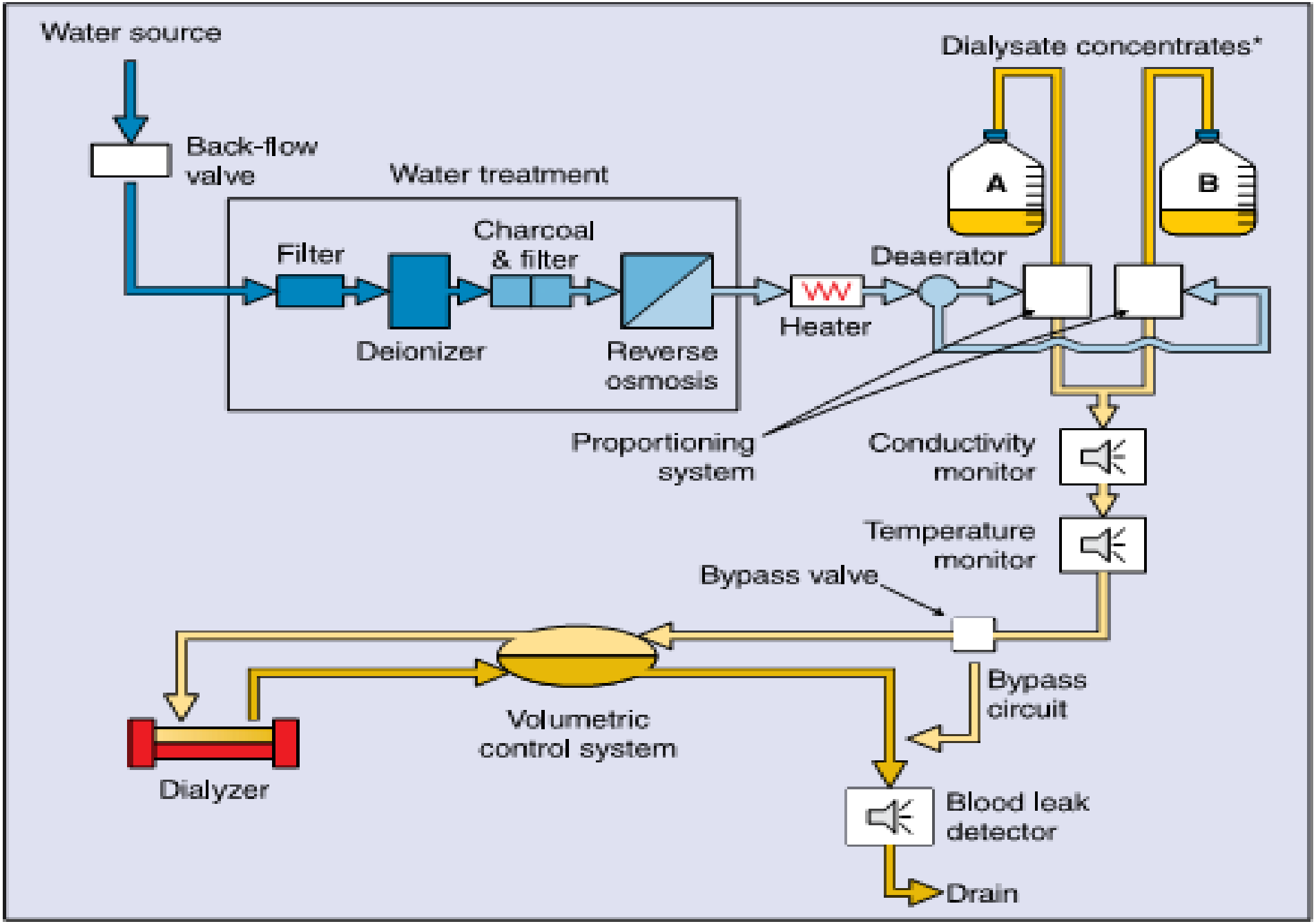
Dialysis Solution

Component	Concentration mmol/L
Na	140
K	2
Ca	1.25 (5 mg/dl)
Mg	0.5 (1.2 mg/dl)
Acetate	3.0
Chloride	108
Bicarbonate	35
Glucose	5.6 (100 mg/dl)

Water Purification


Filters
City Water
Ca, Mg reduced
Backflow preventa
Sediment Filter
Softener
Cl, Chloramine
Carbon
5um / 2 um filters
Feed water
R/O
Drain
Rejected water
Permeate Loop
Dialysis Stations
Water Treatment

Dialysate Circuit



TOXIC WATER CONTAMINANTS

CONTAMINANT	SOURCE	ADVERSE EVENT
ALUMINUM	MUNICIPAL WATER	ENCEPHALOPATHY, BONE DISEASE, ANEMIA
CHLORAMINES	MUNICIPAL WATER	HEMOLYSIS
FLUORIDE	MUNICIPAL WATER	FATAL ARRHYTHMIA, BONE DISEASE (?)
CYANOTOXIN	SOURCE WATER	LIVER FAILURE
NITRATES	SOURCE WATER	ANEMIA
ENDOTOXIN	DIALYSIS UNIT	PYROGENIC REACTIONS, CHRONIC INFLAMMATION
COPPER	DIALYSIS UNIT	HEMOLYSIS, NAUSEA, VOMITING
ZINC	DIALYSIS UNIT	HEMOLYSIS, NAUSEA, VOMITING
CALCIUM, MAGNESIUM	SOURCE WATER, MUNICIPAL WATER	NAUSEA, VOMITING

AAMI WATER QUALITY STANDARDS - 2000 (DRAFT)

SUBSTANCES IN DIALYSATE	
CALCIUM	2
MAGNESIUM	4
SODIUM	70
POTASSIUM	8
TOXIC SUBSTANCES (SDWA)	
ANTIMONY	*0.006*
ARSENIC	0.005
BERYLLIUM	*0.0004*
BARIUM	0.01
CADMIUM	0.001
CHROMIUM	0.014
CYANIDE	*0.02*
LEAD	0.005
MERCURY	0.0002
SELENIUM	0.09
SILVER	0.005
THALIUM	*0.002*

SUBSTANCES TOXIC IN DIALYSIS	
ALUMINUM	0.01
CHLORAMINES	0.10
FREE CHLORINE	0.5
COPPER	0.10
FLUORIDE	0.20
NITRATE (as N)	2.0
SULFATE	100
ZINC	0.10

MICROBIOLOGICAL CONTAMINANTS	
BACTERIA	200
ACTION LEVEL	*50*
ENDOTOXIN	*2*
ACTION LEVEL	*1*

CHEMICAL CONCENTRATIONS IN mg/L, BACTERIA CFU/ml, ENDOTOXIN EU/ml

Vascular Access

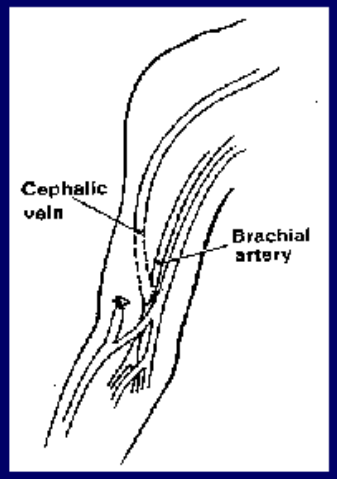
Types Of Vascular Access

- Arteriovenous fistula (AVF)
- Prosthetic bridge graft (PBG)
- Tunneled-cuffed catheter (TCC)

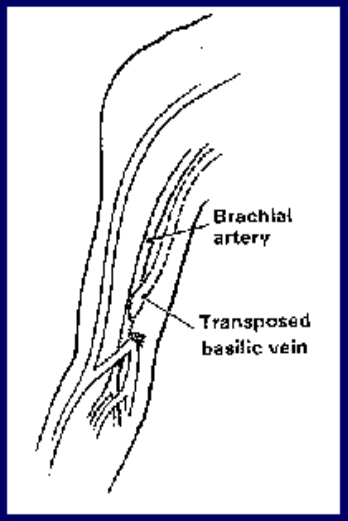
A-V Fistula - Advantage

- Long term patency vs PBG
  - 67% better at age 40
  - 54% better at age 50
  - 24% better at age 65
- Infection rate vs PBG
  - One -tenth

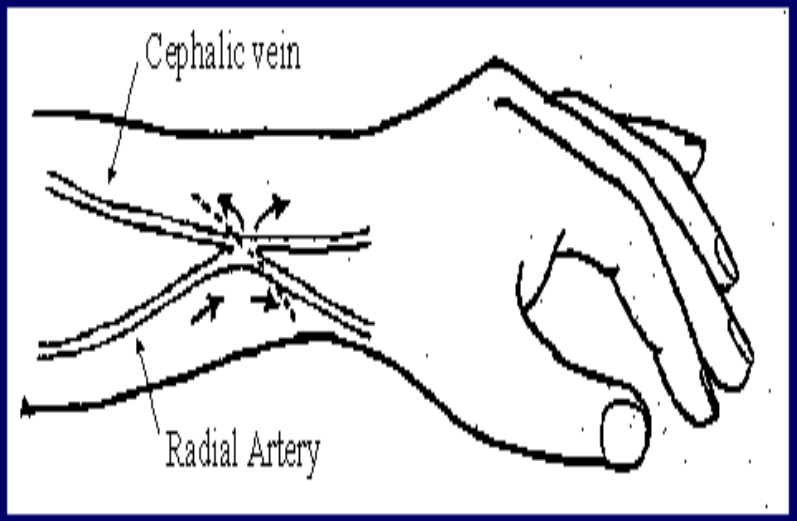
Brachio-Cephalic Fistula



Brachio-Basilic Fistula



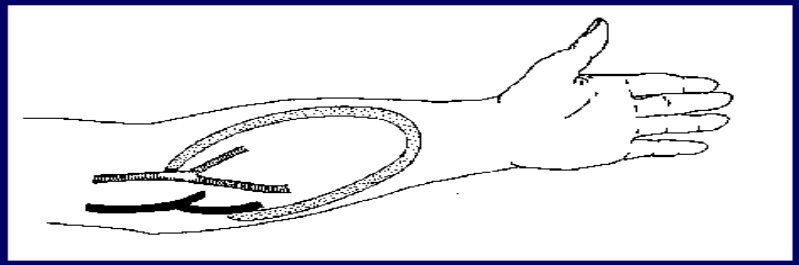
Radio-Cephalic Fistula



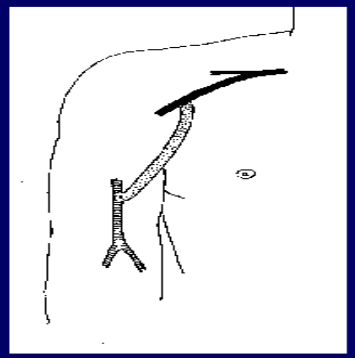
Prosthetic Bridge Graft

- **Advantage:**
  - Wide applicability
  - Use early
  - Works well
  - Large sticking area
- **Disadvantage:**
  - Venous stenosis
    - Inadequate dialysis
    - Recurrent thrombosis
    - Limited life (50 - 60% at 2 years)
  - Infection

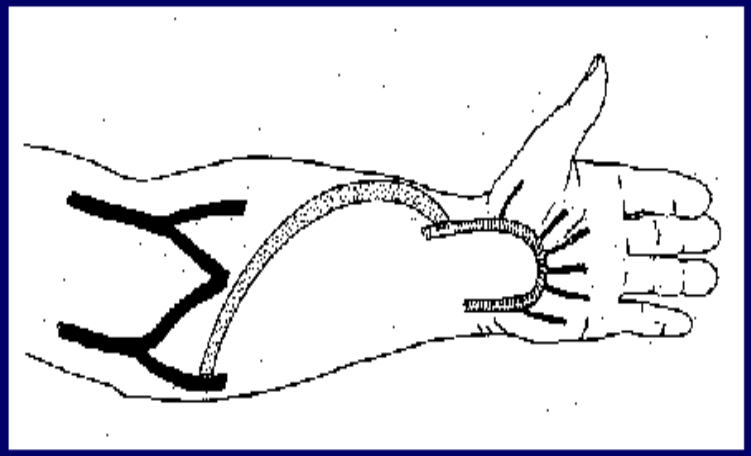
Loop Graft



Upper Arm Graft



Straight Graft



Tunneled Cuffed Catheter

- **Advantage:**
  - Wide applicability
  - Easily placed
  - Use immediately
- **Disadvantage:**
  - Poor flow
  - Loss of function
  - Infection

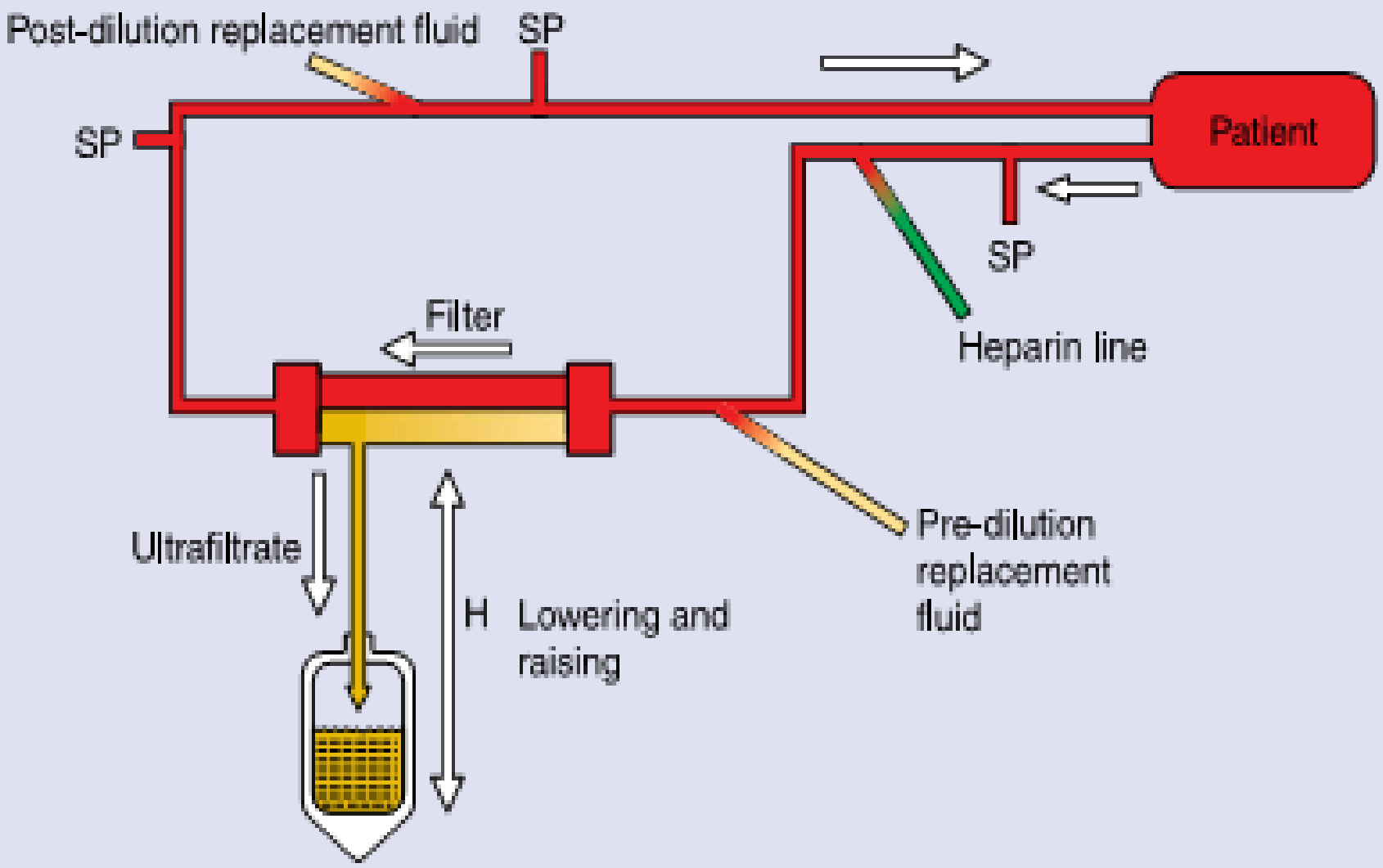
Temporary Catheter in RIJ

Tunneled, Cuffed Catheter for Long-Term Use

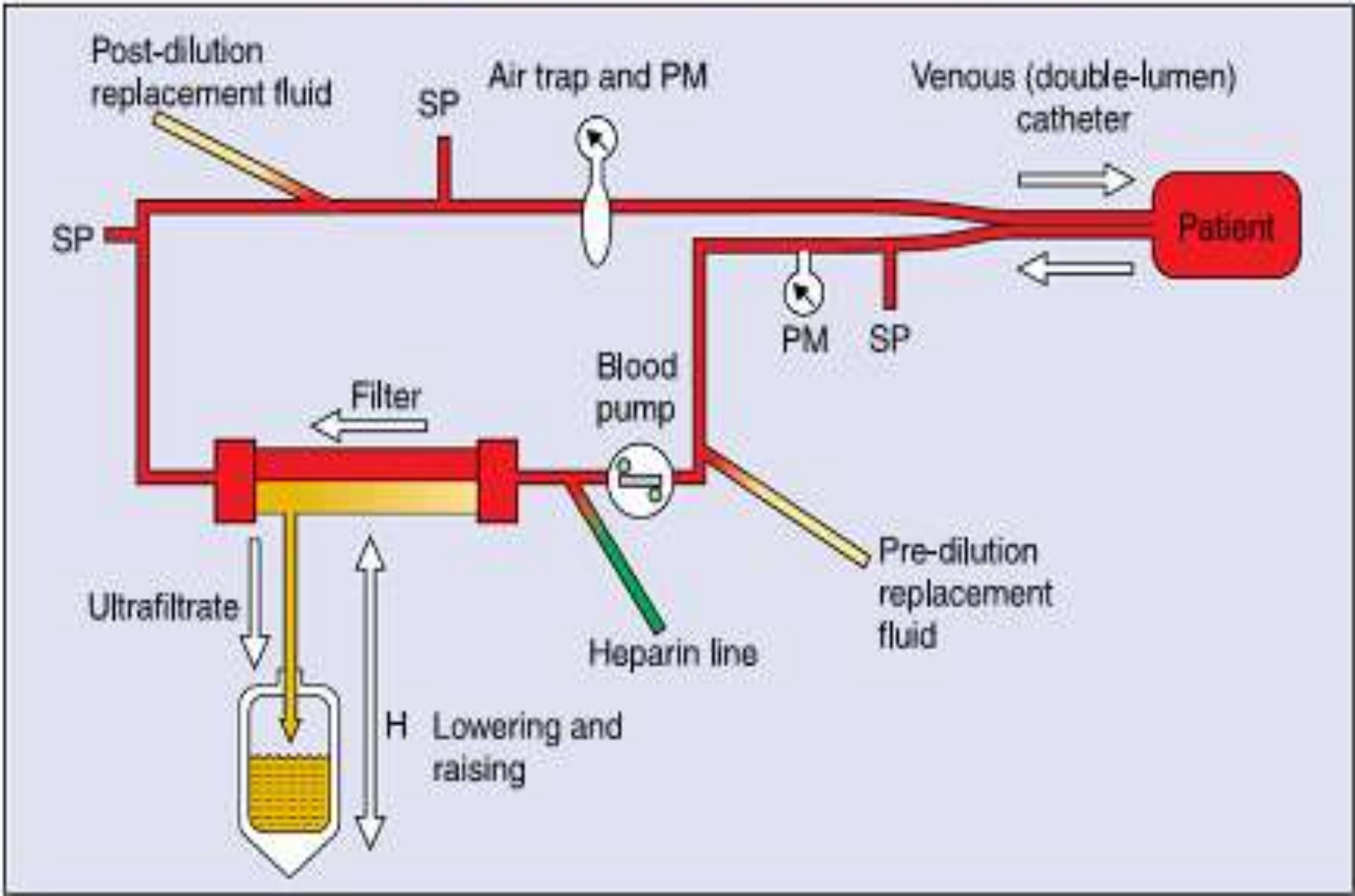
Types of Continuous Therapies

- Continuous arteriovenous hemofiltration (CAVH)
- Continuous venovenous hemofiltration (CVVH)
- Continuous venovenous hemodialysis (CVVHD)
- Continuous venovenous hemodiafiltration (CVVHDF)
- Slow low-efficiency diffusion hemodialysis (SLEDD)
- Slow continuous ultrafiltration (SCUF)

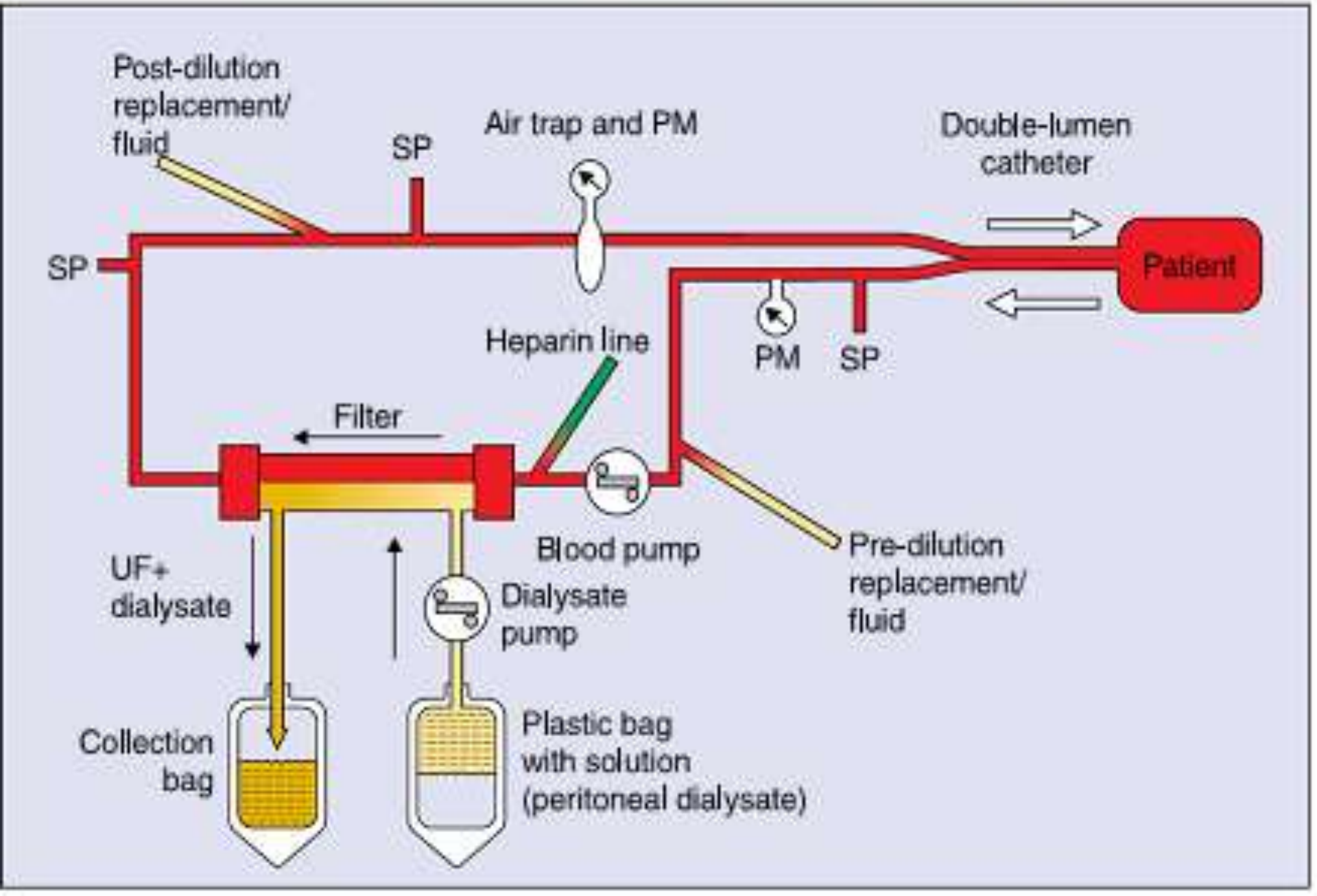
Continuous Arteriovenous Hemofiltration Set-up



Continuous Venovenous Hemofiltration Set-up



Continuous Venovenous Hemodiafiltration Set-up



Indications for initiating Hemodialysis

- In patients with *calculated* creatinine clearance <20 ml/min/1.73 m_2 the onset of:

*Uremic symptoms

Nausea/emesis

Altered sleep pattern

*Altered mental status

Coma

Stupor

Tremor

Asterixis

Clonus

Seizures

Indications for Hemodialysis

*Pericarditis or Tamponade (urgent indication)

*Uremic platelet dysfunction (urgent indication)

*Refractory volume overload

*Refractory hyperkalemia

*Refractory Metabolic acidosis with anuria

- Non renal :

1. Sepsis
2. Drug removal
3. ARDS
4. Resistant CHF
5. Tumor lysis syndrome

THANK YOU